Gø8G 1/127

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

WIPO OMPI

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 : G08G 1/12	A1	(11) International Publication Number: WO 83/ 04451 (43) International Publication Date: 22 December 1983 (22.12.83)

(21) International Application Number: PCT/DK83/00059

(22) International Filing Date: 7 June 1983 (07.06.83)

(31) Priority Application Number: 2553/82

(32) Priority Date: 7 June 1982 (07.06.82)

(33) Priority Country: DK

(71) Applicant: STORNO A/S [DK/DK]; Artillerivej 126, DK-2300 København S. (DK).

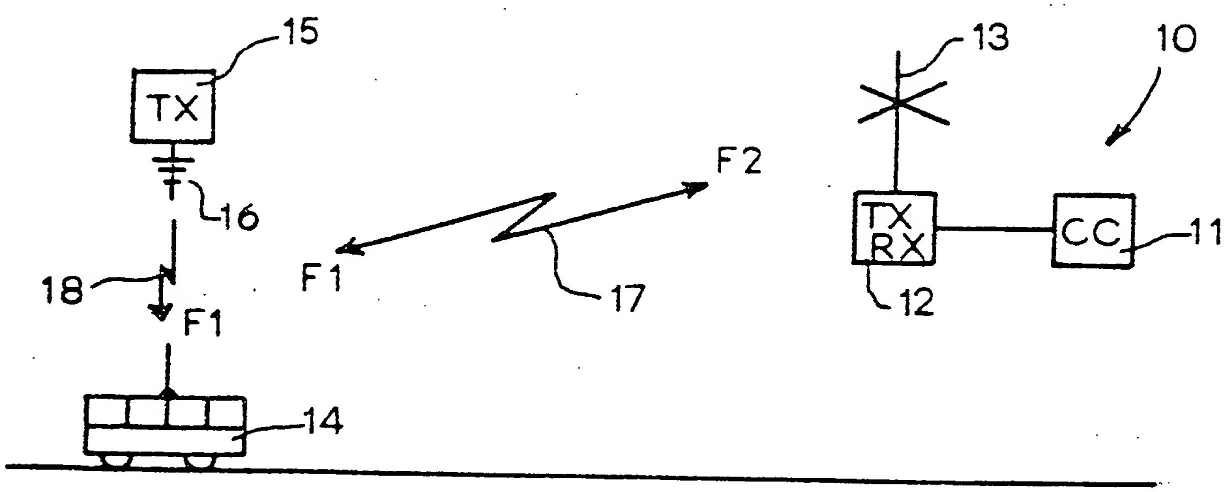
(72) Inventors: AGGERHOLM, Svend ; Lærkevangen 7, DK-3520 Farum (DK). BØTHUN, Oddvar ; Amsterdamvej 28, DK-2300 København S (DK). HANSEN, Flemming ; Hjortevænget 9, DK-2880 Bagsværd (DK).

(74) Agent: WIBERT & STOCKLUND ApS; Ny Kongensgade 21, DK-1557 København V (DK).

(81) Designated States: DE, FR (European patent), GB, SE.

Published
With international search report.
In English translation (filed in Danish).

(54) Title: A LOCATION MONITORING SYSTEM



(57) Abstract

In a location monitoring system for monitoring the location of a plurality of mobile units operating on preestablished routes from a centrally located control station, and where each mobile unit (14) communicates partly with a base station (10), partly with signposts (15, 16) located in specific positions along the known routes, from which the mobile units (14) receive position-specific information during passage, the transmitters (12, 15) in both the base station (10) and in each individual signpost (15, 16) are arranged to have the same operating frequency (F1). This saves an extra receiver in each of the mobile units (14) while minimizing the need for transmission channels. Moreover, the antenna (16) of the signpost has been given a signal emission in a narrow range around it and with such signal strength that the message acceptance to the signals of a signpost (15, 16) during the passage thereof is reasonably good (50%), and at the same time the probability that a message from the base station (10) is not received is very low (=0.1).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	LI	Liechtenstein
AU	Australia	LK	Sri Lanka
BE	Belgium	LU	Luxembourg
BR	Brazil	MC	Monaco
CF	Central African Republic	MG	Madagascar
CG	Congo	MR	Mauritania
CH	Switzerland	MW	Malawi
CM	Cameroon	NL	Netherlands
DE	Germany, Federal Republic of	NO	Norway
DK	Denmark	RO	Romania
FI	Finland	SE	Sweden
FR	France	SN	Senegal
GA	Gabon	SU	Soviet Union
GB	United Kingdom	TD	Chad
HU	Hungary	TG	Togo
JP	Japan	US	United States of America
KP	Democratic People's Republic of Korea		

A location monitoring system

Technical Field

The invention concerns a system for monitoring the location of a plurality of mobile units operating on preestablished routes from a centrally located control station, said system comprising a stationary base station covering one or more transmission channels with a transmitter and a receiver for each channel for selective radio communication with the mobile units comprised by the system, said mobile units similarly comprising a transmitter and a receiver for radio communication with said base station, and with signposts located in specific positions along the known routes, each of said signposts being provided with a short range transmitter for transmitting during the passage thereof position-specific information to a storage means provided in a mobile unit.

Background Art

A system of the above-mentioned type is known in many embodiments and is primarily used for monitoring e.g. the public bus service. In order most efficiently to utilize the available rolling equipment and to provide a reasonably good service to the public, it is necessary that e.g. the scheduled arrivals and departures are maintained as close as possible. However, also other regards than the maintenance of schedules have justified the establishment and maintenance of a location monitoring system, through which it is possible at any time to get an exact survey of where in the system of routes each individual mobile unit is positioned.

For example in case of traffic jams, the individual units can be diverted and controlled from the base station. A system of the above-mentioned type is useful not only in connection with the public transport of passengers, but has also proved its usefulness in connection with e.g. money transports or patrols of different kinds.

Communications between the signposts and the individual mobile units take place wirelessly and are based on different techniques, but most of them are unsuitable in the present use. Thus, communications with infrared light have only a limited range, and the same applies to communications with ultrasound, which has moreover a poor signal/noise ratio. RF-communications at very low frequencies are known in connection with rail traffic, but this technique is expensive and difficult to maintain.

Radio communications in the microwave range constitute the most frequently used method owing to its reliability and accuracy, but is very expensive.

The apparatus used in the VHF/UHF range, on the other hand, is less expensive, but then there is a lot of traffic in the air so that it may be difficult to get the required number of communications channels from the teleadministrations.

The Danish Patent Specification 132 475 discloses a traffic monitoring system, in which a sequence of messages is continuously transmitted from a traffic control centre, each containing its address of a bus, and information is received from each bus about its position at the time of reply. The interrogation messages are transmitted on one frequency, the interrogation frequency, while the reply messages from the individual buses are transmitted on another frequency, the reply frequency. This part of the communications between the traffic control centre and each individual bus takes place digitally. In addition to this, the known system provides a facility for communicating at voice communications level between the driver and the traffic control centre, which takes place on another channel, the voice communications channel.

Moreover, each individual bus receives position-specific information during the passage of a signpost, which continuously

transmits messages containing an identification code specific of the signpost in question. Each signpost comprises a digital position generator whose output signal is converted by FSK technique into tones used for modulating a constantly operating transmitter.

Thus, it is a considerable technical array which is involved in this known traffic monitoring system with separate transmitters and receivers for communications between the bus and the traffic control centre and between the bus and signposts, respectively, simultaneously with the occupation of five different communications channels or frequencies.

Disclosure of Invention

A location monitoring system of the type stated in the opening paragraph is characterized according to the invention in that the transmitter at the base station and the transmitter in each signpost are arranged to transmit on the same frequency, and that the transmitter of the signpost comprises an antenna with a signal emission so arranged that in a narrow range around the signpost its level is so high above the mean level of the signal emitted from the base station that a satisfactory acceptance of the signal received from the signpost is obtained, and decreases so that the signal strength from the signpost at a suitable distance at either side of the said post has decreased to such a low level below the mean level of the signal emitted from the base station that satisfactory acceptance of the signal received from the base station is obtained.

The features of the invention involve several advantages.

When the base station and the individual signposts transmit on the same frequency, the stationary equipment is simplified and thus made cheaper because at both points it allows the use of the same equipment as for other RF purposes. The communica-

tions equipment in the mobile units is also made cheaper in that at least one receiver is saved per unit. Finally, the need for communications channels or frequencies, which is a scanty resource, is reduced in that only a single channel is occupied instead of two like in the known system.

Brief Description of Drawings

The invention is explained more fully below with reference to the drawings, in which

fig. 1 is a schematic view of the individual main components of a location monitoring system,

fig. 2 shows the units incorporated in the transmitter/receiver equipment of a mobile unit,

fig. 3 shows, for different signal levels, the message acceptance as a function of the difference in level between the signal strength of two signals on the same frequency,

fig. 4 shows the relative signal level from the antenna of a signpost as a function of the relative distance in the direction of motion,

fig. 5 is a sketch to illustrate the coverage profile of a base station, and

fig. 6 is a diagram of a modified transmitter/receiver in a mobile unit.

Best Mode of Carrying Out the Invention

In fig. 1 a stationary base station is generally designated by 10. In principle it comprises a central computer 11 containing all relevant information about the mobile units forming part of the system, the routes to be traversed, and the points of time when these units are scheduled to pass specific positions in the system of routes, and a transmitter/receiver part 12 which is in radio contact with a mobile unit 14 via an antenna 13. Also, the base station comprises the usual equipment for such a station for the monitoring of the system of routes, such as control desks with display and

printer units and radio telephony equipment for the setting up of voice communications connections with any of the mobile units in the system but such equipment is ordinary and does not concern the invention, and is accordingly not shown in the drawing. The same applies to the interface equipment between the central computer 11 and the transmitter/receiver part 12.

In the drawing the mobile unit (14) issymbolized by a vehicle of a type, e.g. a bus; the essential feature to the system, however, is that each mobile unit 14 follows a known route and passes certain fixed points on the route. Such a fixed point is marked by a signpost 15, which is in principle a transmitter which, through an antenna 16, constantly emits a signal of a suitable strength and containing information about the position of the signpost in question in the system of routes.

A sequence of interrogation messages is emitted from the base station 10, each containing its individual address to a mobile unit 14 which upon reception of an interrogation message transmits its reply message containing the identification code for the unit in question and information about its current position. This communication between the base station 10 and the mobile units 14 takes place through two channels, an interrogation channel of the frequency F1 and a reply channel of the frequency F2 as marked by a double arrow 17.

The position of the signpost 15 is transmitted to the mobile unit 14 during the passage thereof, and this information is stored in a known manner in a store until passage of the following signpost in the system. The travelled distance between two signposts is measured continuously e.g. by means of an odometer, and this measured value is applied to the position store likewise in a known manner, so that the position information transmitted with the reply message is correct within a certain margin.

According to the invention, all the signposts 15 transmit on the same frequency F1 as the base station 10, which is indicated by a single arrow 18. This involves the advantage that an extra receiver is saved in each mobile unit while minimizing the need for transmission channels. It is not unknown that it is difficult, if not impossible, to find free channels in the VHF/UHF band.

Fig. 2 shows the most important units of the invention which are incorporated in the transmitter/receiver equipment of a mobile unit 14. Via an antenna 21 the mobile unit receives a message from the base station 10 or from a signpost 15, and this message is passed on through a bandpass filter 22 of the centre frequency F1 to a receiver 23. The receiver selects the received messages so that only the message from the base station 10 which has the correct address, or a message from a signpost 15 causes a response. This consists in the storage of the position code of a signpost in a control unit 24, which also receives information from an odometer (not shown) about the travelled distance since the last passage of a signpost, or the response is that an accepted interrogation message causes the information on the position which is stored at the given point of time in the control unit 24 to be transmitted to a transmitter 25, which transmits this information together with the identification code of the mobile unit through another bandpass filter 26 of the centre frequency F2.

In order for the communications between the base station and the mobile unit and between the signpost and the mobile unit, respectively, to take place expediently, it is necessary that certain criteria are met. Firstly, it is necessary that the message acceptance is reasonably high both on reception of interrogation messages from the base station and on reception of position messages during the passage of a signpost. Secondly, the emission diagram of the signpost antenna 16 must be

so narrow that its position is defined with reasonable accuracy, and so narrow with respect to the spacing between the signposts that the probability of non-acceptance of an interrogation message is reasonably low, but not so narrow that the message acceptance is too poor during the passage of a signpost at normal average speed. This calls for a certain minimum spacing between the individual signposts.

If an experiment is made with two different transmitters transmitting on the same frequency but with different levels, with a view to determining the order of the message acceptance as a function of the difference in level at the reception location between the signal strength of the two transmitters, it will be found that the message acceptance is 50% already at a difference in level of only 6 dB, while a message acceptance of 95% requires a difference in level of about 24 dB, and these values are fairly independent of the absolute signal level. This appears from fig. 3 where this relation is plotted in a system of coordinates with the message acceptance in % plotted along the ordinate and the difference in level in the signal strength of the transmitters measured in dB along the abscissa.

Fig. 4 shows an emission diagram for a two-element halfwave end-fire antenna suitable as an antenna 16 for a signpost 15. The ordinate of the diagram indicates the mean value of the relative signal level in dB, and its abscissa the relative distance in metres calculated in the direction of motion of a mobile unit forming part of the system. As expected, the diagram is relatively symmetrical about the axis of the antenna and exhibits a narrow opening angle. About 10 m at either side of the signpost the signal level has already decreased 6dB with respect to maximum signal strength in the main direction of the antenna, and just under 50 m to the side the signal strength of the antenna has decreased by a further 20 dB. If the transmitter strength of the individual signpost 15 is arranged in such a manner that the 6dB level is equal to the mean

level of the signal from the base station 10, the message acceptance of a message transmitted from a signpost is about 50%, cf. the curves in fig. 3, and if a mobile unit passes a signpost at an average speed of 10 m/s, the unit receives about 5 to 10 messages from the signpost, the duration of a message including interval being about 100 ms. Thus, it is ensured that the mobile unit receives the position information from the signpost passed and stores it for subsequent transmission to the base station.

Similar operating conditions can be obtained with other antenna forms, such as reflector antennas or more complex antenna systems.

It moreover appears from fig. 4 that the signal strength from the signpost about 50 m to its side has decreased to a level of about 20 dB below the mean level of signals from the base station, and at this point the message acceptance of a message from the base station 10 is about 90%, cf. fig. 3. This would be excellent if the base station constantly transmitted messages of the same address, but since this is not the case, it is necessary to have a certain minimum spacing between the signposts if the probability that a mobile unit does not receive a call from the base station is not to be too great.

In fig. 5 the coverage profile of the base station is illustrated. The spacing between the signposts is designated by a, and the trapezoidal curves between them indicate the message acceptance of messages from the base station. The spacing b indicates the length of the distance opposite a signpost where the acceptance is less than 90%. If a message acceptance completely outside the operating ranges of the signposts of 95% is required, and if this quantity is called $1-P_o$, it can be shown that the probability P that a mobile unit does not receive a message from the base station can be expressed

by:

$$P=P_o + b/a\ (1-P_o)$$

hence the minimum spacing between the signposts:

$$a_{min}=b\ (1-P_o)/(P-P_o).$$

If b = 100 m, P = 0.1 and P_o = 0.05, a minimum spacing a_{min} = 2 km results.

The numerical examples in the foregoing must not be interpreted restrictively, however, because the determination of the described differences in level in signal strengths e.g. greatly depend upon which message acceptance levels are found satisfactory in given situations.

It may occur, however, that the interrogation frequency F1 allocated to a base station 10 is too low for the same frequency to be used as an operating frequency for the signposts because the emission angle of the antennas 16 then cannot be kept as narrow as desired according to the foregoing. In that case, according to the invention, the transmitter equipment in each mobile unit can be extended with an own oscillator and frequency converter, so that the mobile unit still uses the same receiver as before. This extension is shown in fig. 6. With respect to the diagram in fig. 2, the extension consists in a dividing network 31 for the operating frequency Fb of the signpost, said dividing network 31 passing on the signal from the antenna 21 through an amplifier 32 to a frequency converter 33, which receives a signal from an own oscillator 34 oscillating on the frequency Fb-F1. The signal composed by the converter 33 is passed through a bandpass filter 35 of the centre frequency F1 and now contains the information which was transmitted to the antenna 21 on the operating frequency Fb. The signal is conveyed to the receiver through an addition link 36. To provide for a situation where the operating frequency of the base station is too low with respect to the optimum one desirable for the signposts thus just requires an additional technical array of a modest extent.

P A T E N T C L A I M S

1. A system for monitoring the location of a plurality of mobile units operating on preestablished routes from a centrally located control station, said system comprising a stationary base station (10) covering one or more transmission channels with a transmitter and a receiver (12) for each channel for selective radio communication with the mobile units (14) comprised by the system, said mobile units similarly comprising a transmitter (25) and a receiver (23) for radio communication with said base station (10), and with signposts located in specific positions along the known routes, each of said signposts being provided with a short range transmitter (15) for transmitting during the passage thereof position-specific information to a storage means (24) provided in a mobile unit (14), c h a r a c t e r i z e d in that the transmitter (12) at the base station (10) and the transmitter (15) in each individual signpost are arranged to transmit on the same frequency (F1), and that the transmitter (15) of the signpost comprises an antenna (16) with a signal emission so arranged that in a narrow range around the signpost its level is so high above the mean level of the signal emitted from the base station (10) that a satisfactory acceptance of the signal received from the signpost is obtained, and decreases so that the signal strength from the signpost (15,16) at a suitable distance at either side of the said post has decreased to such a low level below the mean level of the signal emitted from the base station (10) that satisfactory acceptance of this received signal is obtained.

2. A system as claimed in claim 1, in which the operating frequency (F1) of the base station (10) is alternatively much lower than the operating frequency (Fb) of the signposts (15, 16), c h a r a c t e r i z e d in that additional circuits (31-36) are coupled in each mobile unit (14) in front of the receive (23) for frequency conversion from the operating freqdency (Fb)

of a signpost (15,16) to the operating frequency (F1) of the base station (10), while maintaining the position-specific information transmitted from a signpost to the receiver (23) of a mobile unit (14).

3. A system as claimed in claim 2, characterized in that said additional circuits comprise a series connection of a dividing filter (31) for the operating frequency (Fb) of the signpost, an amplifier (32), a frequency converter (33), a bandpass filter (35) of the centre frequency equal to the operating frequency (F1) of the base station (10) and an addition link (36), said series connection being inserted between the receiver (23) and an antenna (21), said frequency converter (33) having coupled to it an oscillator (34) of an oscillation frequency equal to the difference between the operating frequencies (Fb-F1) of the signpost and the base station.

1/5

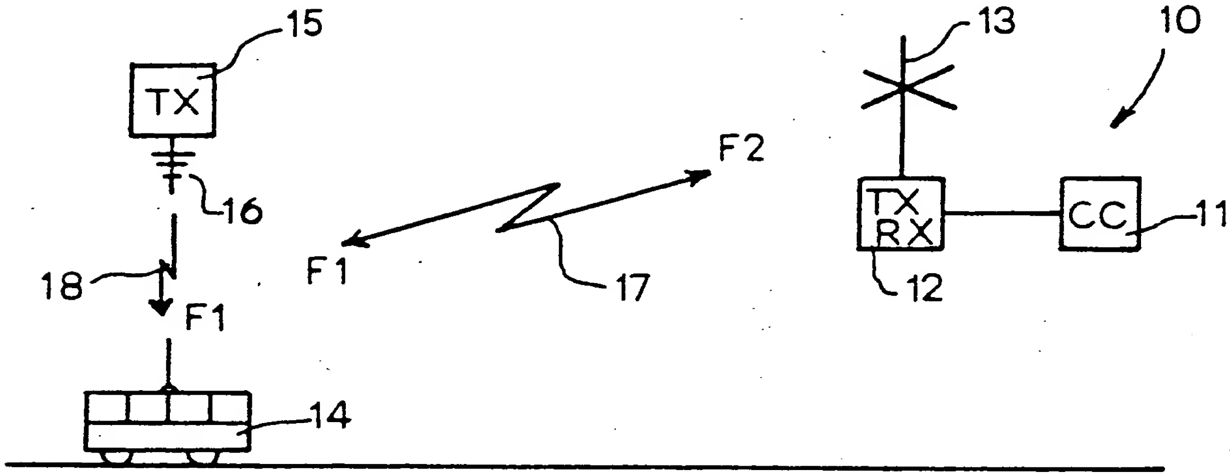

15
TX
16
18
F1
F1
F2
17
13
10
TX
RX
CC
11
12
14

Fig. 1

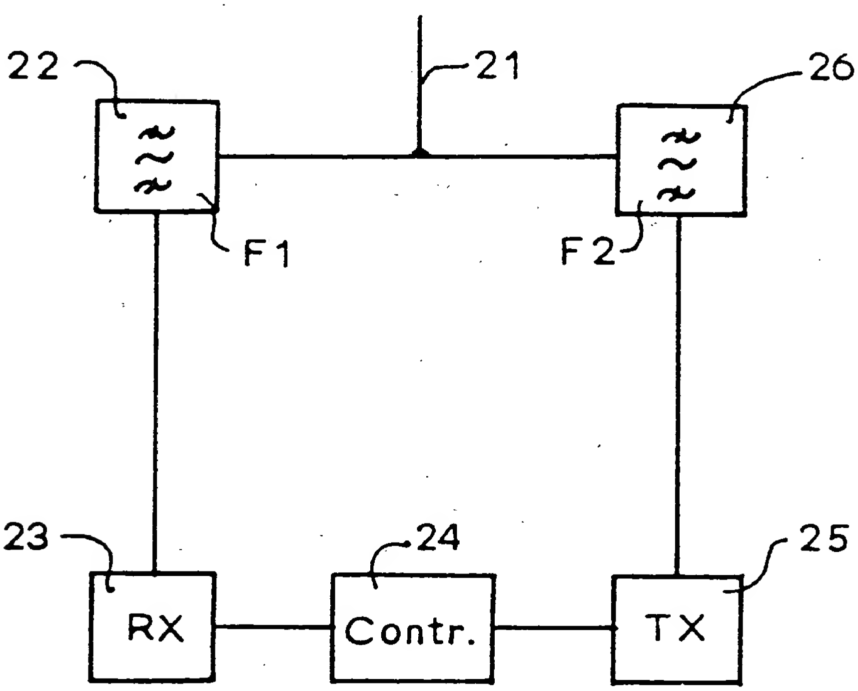

22
21
26
F1
F2
23
24
25
RX
Contr.
TX

Fig. 2

2/5

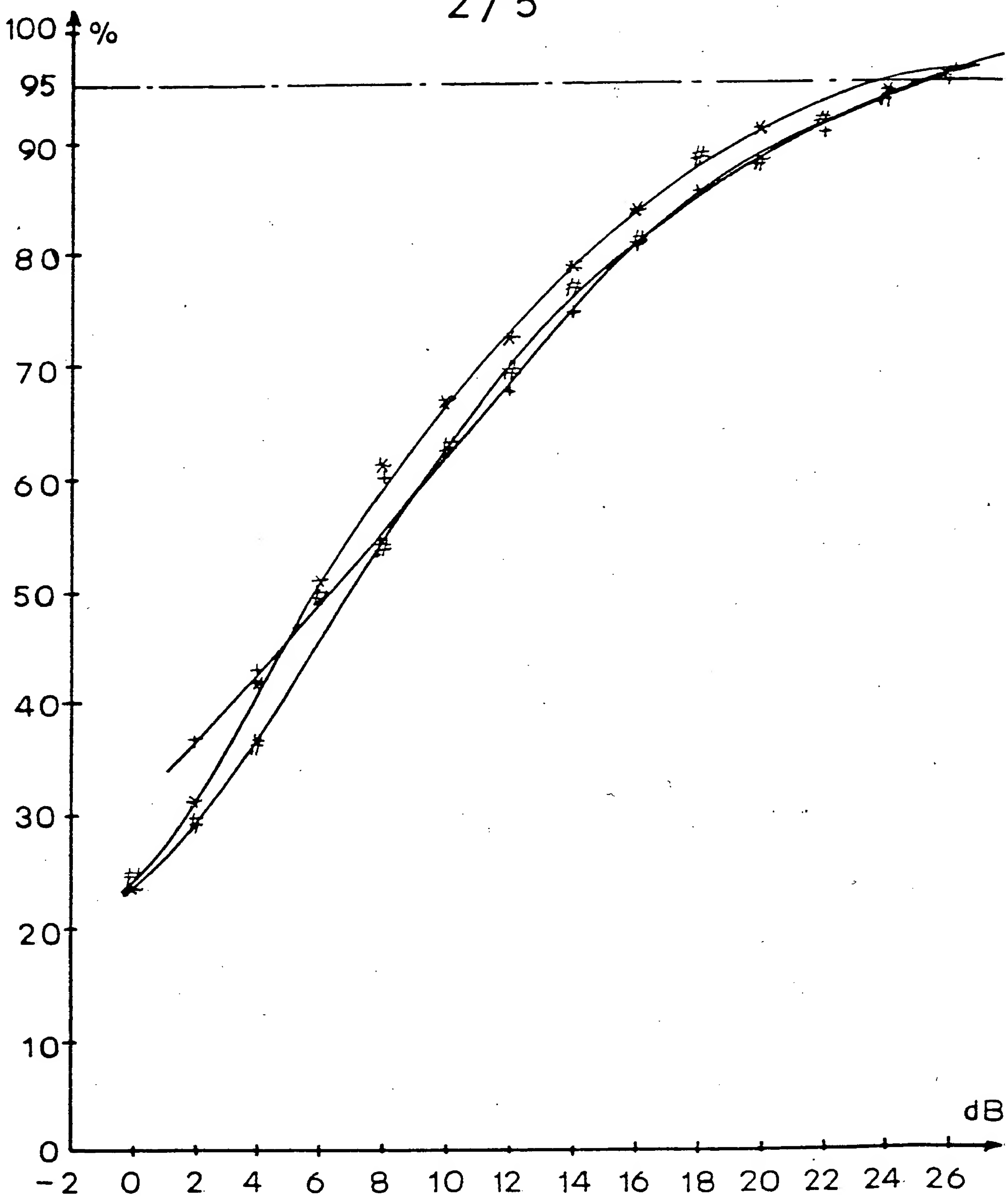

100
%
95
90
80
70
60
50
40
30
20
10
0
dB
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26

Fig. 3

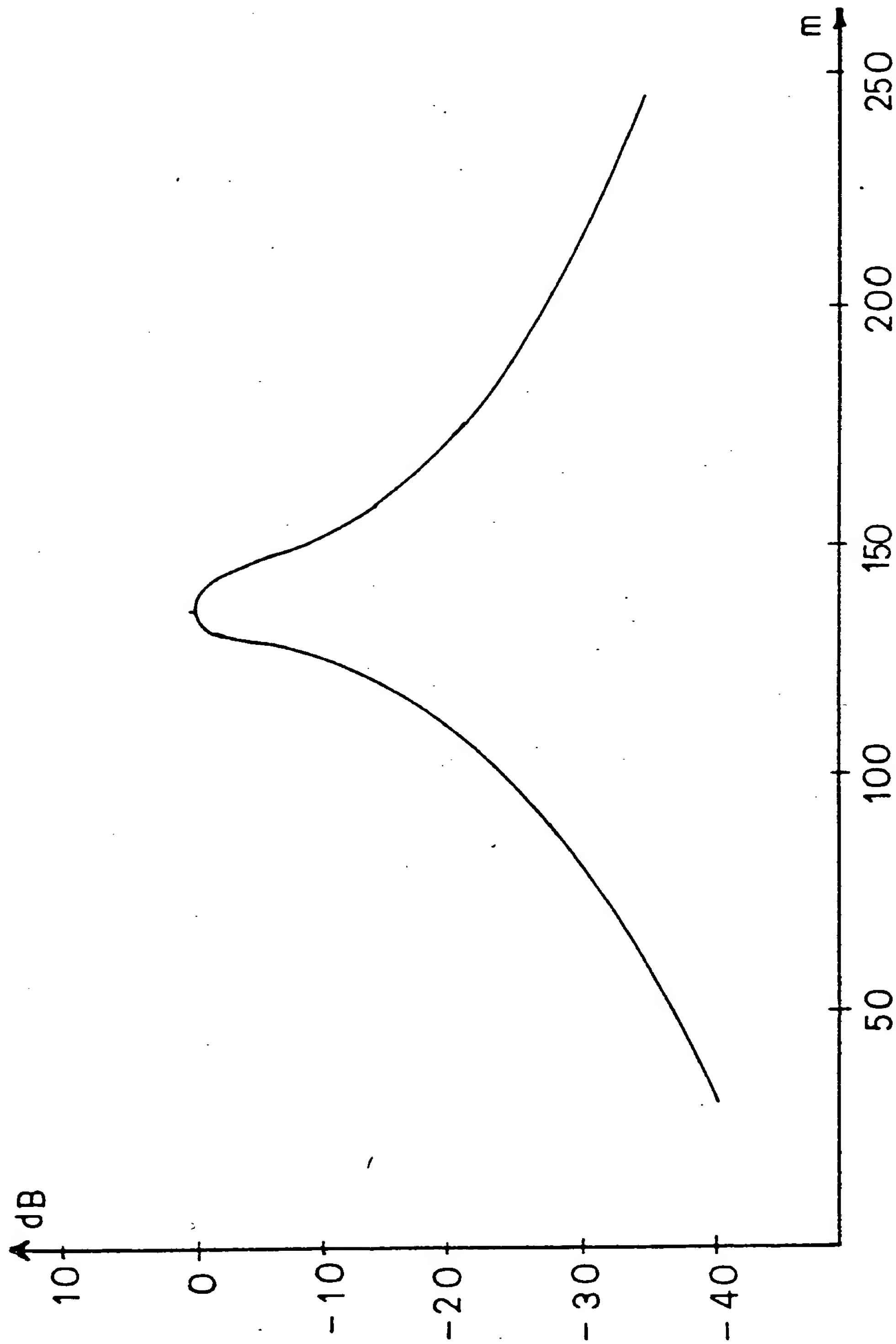


Fig. 4

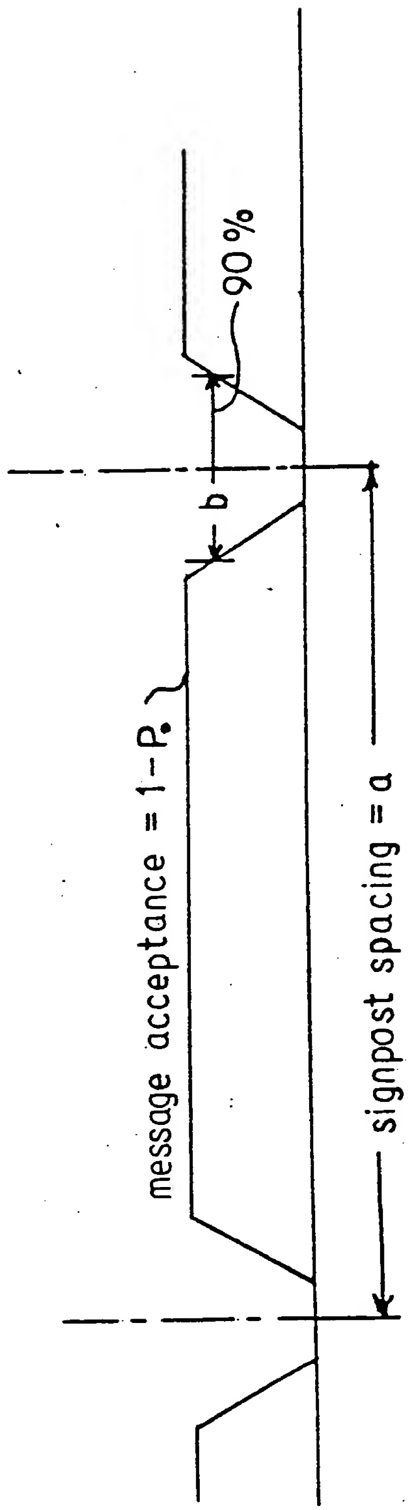


Fig. 5

5/5

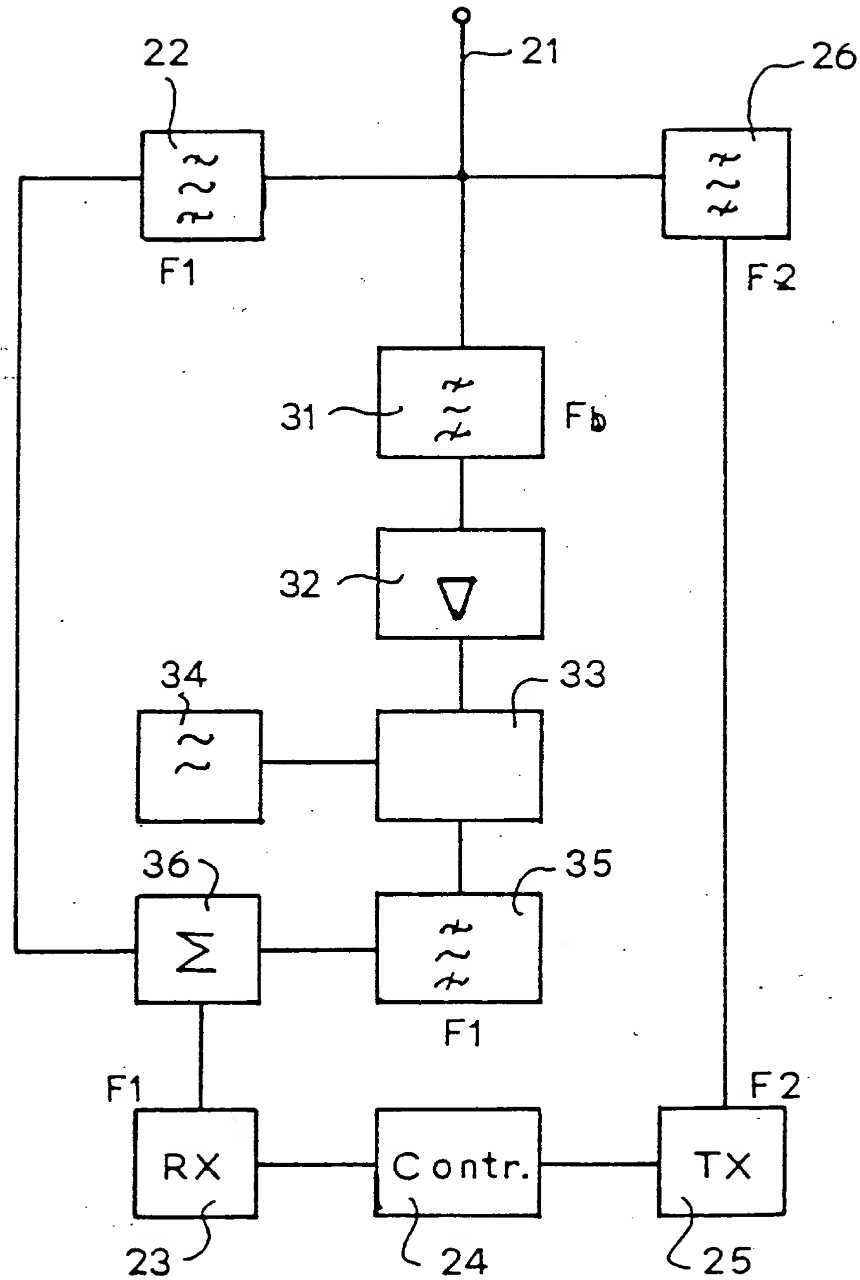


Fig. 6

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK83/00059

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [8]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

G 08 G 1/12

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	G 08 G 1/12, H 04 B 7/26
US Cl	340:23, 24; 343:6.5, 112TC

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	DE, B2, 2 143 474 (LICENTIA PATENT-VERWALTUNGS GmbH) 22 November 1979 1/12 & AU, 45429/72 AU, 465 543	1
X	US, A, 3 697 941 (D CHRIST) 1/12 10 October 1972	2
A	DE, A1, 2 738 811 (MOTOROLA INC) 6 April 1978	
A	US, A, 3 644 883 (W BORMAN ET AL) 22 February 1972	
A	US, A, 3 735 335 (G KAPLAN ET AL) 22 May 1973	
A	US, A, 3 757 290 (G ROSS ET AL) 4 September 1973	
A	DE, B2, 2 539 241 (SIEMENS AG) 30 April 1980	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1983-08-05	1983-08-10
International Searching Authority [1]	**Signature of Authorized Officer** [20]
Swedish Patent Office	Göran Magnusson Göran Magnusson